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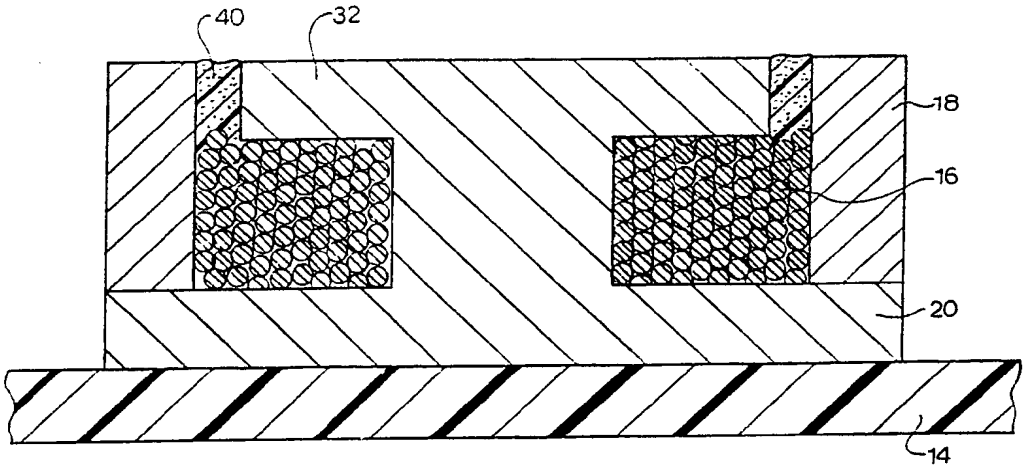
(54) Title: INDUCTIVE DEVICE AND METHOD OF MANUFACTURE



(57) Abstract

An assembly and method of manufacture is described for an inductive device in which the effect of a gap in its enclosure is controlled. This is accomplished by assembling a winding (16) on a core (12), placing a shell (18), sleeve or other closure member over the winding, and then injecting a measured amount of a hardenable vehicle (40) containing particles having selected magnetic properties into the gap (30) existing between the closure member and the core.

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INDUCTIVE DEVICE AND METHOD OF MANUFACTURE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to inductor devices and to methods of manufacturing such devices. More particularly, this invention relates to methods of controlling the effect on the flux lines caused by gaps or spaces in the enclosing magnetic shell surrounding the winding.

Description of the Prior Art

Production of inductive devices has typically involved the winding of a length of wire around a center core. To improve the inductance characteristics of these devices the coil is surrounded by a casing or enclosure of magnetic material to close the flux paths. Such a device is described in U.S. Patent No. 4,498,067. In that reference, a shell is polished at its edges and fitted to edges protruding from the core of the coil. By improving the fit of the shell, the spaces between the shell and the protruding core edges are minimized to thereby improve the inductance.

Another approach is described in U.S. Patent No. 4,769,900; counter-part blocks of molded thermoplastic resin containing magnetic particles are fitted to surround the coil. By custom molding these blocks, a close fit is

obtained thereby minimizing any gaps which would degrade the inductance characteristics. A similar molding technique has also been used to fully encompass the coil. In U.S. Patent No. 3,201,729 and U.S. Patent No. 3,255,512 a coil is placed within a mold and a resin containing magnetic particles is used to fill the mold and completely surround the coil.

Notwithstanding these prior attempts, accuracy and economy have remained elusive for miniaturized inductive devices. Polishing of mating surfaces is expensive and unreliable for mass production. Molding techniques have also proven to be expensive and the desired inductive characteristics of the finished product are difficult to control.

SUMMARY OF THE INVENTION

Accordingly, it is a principal objective of this invention to provide a method for the production of an inductive device of the type having a winding on a core and an enclosing shell, which process yields an economical yet accurate inductive device. This is accomplished by assembling a winding on a core, placing a shell or sleeve closure member over the winding to mate with extending portions of the core and thereby fully encompass the winding, and then injecting an adhesive or epoxy containing particles having selected magnetic properties into the small gap existing between the closure member and the core.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A depicts a bobbin core member of one embodiment of an inductive device used in connection with the present invention.

Figure 1B depicts the bobbin of Figure 1A having a winding wrapped thereon.

Figure 1C is a perspective view of the assembled inductive device having a sleeve placed over the bobbin and winding.

Figure 2 is a cross sectional view of the inductive device of Figure 1C showing the gap between the sleeve and the bobbin core filled with material containing particles having magnetic properties.

Figure 3 is a cross sectional view of another embodiment of an inductive device employing the gap control techniques of the present invention.

Figure 4 is a cross sectional view of another embodiment of an inductive device employing the gap control techniques of the present invention.

Figure 5 is a cross sectional view of yet another embodiment of an inductive device employing the gap control techniques of the present invention.

Figure 6 is a cross sectional view of a further embodiment of an inductive device employing the gap control techniques of the present invention.

Figure 7 is a cross sectional view of still another embodiment of an inductive device employing the gap control techniques of the present invention.

Figure 8 is a cross sectional view of an additional embodiment of an inductive device employing the gap control techniques of the present invention.

While the invention will be described in connection with a preferred embodiment, it will be understood that it is not the intent to limit the invention to that embodiment. On the contrary, it is the intent to cover all alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to the drawings, there is shown in Figures 1A, 1B and 1C the progressive assembly of one example of an inductive device in accordance with the present invention. Particularly, in Figure 1A a bobbin core 12 is shown assembled to a magnetically inert substrate base 14 (typically of a ceramic, plastic or phenol composition). A wire 16 is wound onto the bobbin (Figure 1B) and terminated on the substrate; and a sleeve 18 is fitted over the wire wound bobbin (Figure 1C). The sleeve engages the bobbin to form an enclosure surrounding the winding; and the core and sleeve are usually composed of ferrite or iron materials to thereby close the magnetic flux lines developed by the device. Typically, the bobbin core is adhered to the substrate base and the sleeve is adhered to the lower portion of the bobbin.

Following this assembly, it is well known in the manufacturing industry that a small gap 30 circumscribing the upper part 32 of the bobbin exists between the sleeve and the bobbin, and that this space interrupts the flux lines and degrades the inductance characteristics of the device. Perhaps more importantly, the existence of this gap makes the manufacture of inductive devices of the desired characteristics and tolerance difficult to achieve.

In accordance with the present invention, a filler material 40 carrying selected particles of a desired magnetic characteristic dispersed therethrough is inserted into the gap to thereby provide a determinable effect on the flux lines. This inserted material is preferably of a formable or flowable type in the nature of an adhesive, plastic resin or epoxy which hardens or may be hardened once it is in place. Distributed throughout this material are selected particles of either magnetic or non-magnetic properties, or a combination thereof, of such size, quantity and ratio as to provide desired requisite magnetic properties. An example of such magnetic materials are ferrite or iron particles, and examples of such non-magnetic materials are aluminum or brass. By selecting a particular grain size, a concentration of particles or a desired combination of particles, then for a given configuration of an inductive device, the effect of the gap in the enclosing casing may be effectively controlled by inserting therein a measured quantity of the filler material to yield fairly precise manufacturing tolerances for the characteristics of the inductor.

Control of the flux characteristics of the encasing shell of an inductive device by the selection of a quantity of filler material containing a prescribed concentration, grain size, and type or ratio of particles is further exemplified by the embodiments shown in Figures 3-8. In each case a winding 50a-50f is wound about a core member 52a-52f. When the sleeve, shell or other encasing enclosure 54a-54f is added to mate with portions of

the core member, a space 56a-56f is created which adversely affects the characteristics of the device. This space or "gap" is then filled with a vehicle of hardenable material having selected particles dispersed therein in accordance with the above described principles of the present invention.

As before, examples of such a hardenable material are adhesives, thermoplastic resins and epoxies. Particles dispersed in the vehicle may be of a magnetic material, such as a ferrite or iron particles, to increase the inductance or they may be a non-magnetic material, such as aluminum or brass, to decrease the inductance, or they may be a combination of these types. During manufacture, the quantity of the particles, the size of the particles or the selected combination of particles may be adjusted and the amount of material inserted into the gap area may be controlled to achieve the desired inductive characteristics for the device.

From the foregoing description, it will be apparent that modifications can be made to the apparatus and method for using same without departing from the teachings of the present invention. Accordingly, the scope of the invention is only to be limited as necessitated by the accompanying claims.

CLAIMS

1. An inductive device comprising a core, a winding on said core, a closure member for engaging said core and thereby substantially enclosing said winding, a gap between portions of said closure member and said core, and filler material having selected magnetic properties positioned in said gap.

2. The inductive device of Claim 1 wherein said filler material is a flowable material which is hardenable once positioned and contains particles dispersed throughout, said particles being selected to have desired magnetic properties.

3. The inductive device of Claim 2 wherein said filler material contains a mixture of particles of differing magnetic properties dispersed in said filler material in a predetermined ratio.

4. The inductive device of Claim 1 wherein said core exhibits a bobbin construction and said closure member comprises a sleeve arranged to envelop said bobbin and to mate with the ends thereof, and wherein said filler material comprises an epoxy resinous material containing particles of ferrite composition dispersed throughout which is injected into gaps between said sleeve and the ends of said bobbin.

5. An inductive device constructed by the assembly of a core, a winding wrapped on said core, a closure member arranged to engage said core and thereby substantially enclose said winding, said engagement of said closure member and said core leaving a gap between portions of said core and said closure member; and wherein said assembly is further constructed by inserting filler material into selected gap portions for affecting the magnetic properties of said device, said filler material being inserted by injecting into said gap a quantity of flowable material containing particles of selected magnetic properties, which flowable material is hardenable once in position.

6. The inductive device of Claim 5 wherein said assembly is further constructed by determining the magnetic effect required by said filler material to produce the desired characteristics of the inductive device, and selecting particles for dispersal in said filler material, which

particles will produce said desired effect, and dispersing said particles within said filler material prior to inserting said filler material.

7. The inductive device of Claim 6 wherein said particle selection includes one or more of the following criteria; selection of particle type by its magnetic characteristics, selection of particle size, selection of a ratio of particle types, and selection of particle concentration in said filler material.

8. The inductive device of Claim 6 wherein said core exhibits a bobbin construction and said closure member comprises a sleeve arranged to envelop said bobbin and to mate with the ends thereof, and wherein said filler material comprises an epoxy resinous material containing particles of ferrite composition dispersed throughout which is injected into the gap between said sleeve and the ends of said bobbin.

9. A method of manufacturing an inductive device comprising the steps of winding a coil onto a core, placing a closure member in engagement with said core thereby substantially enclosing said winding but leaving a gap between portions of said closure member and said core, and injecting into said gap a quantity of flowable material containing particles of selected magnetic properties.

10. The method of manufacturing an inductive device of Claim 9 wherein said particle selection includes one or more of the following criteria; selection of particle type by its magnetic characteristics, selection of particle size, selection of a ratio of particle types, and selection of particle concentration in said filler material.

11. The method of manufacturing an inductive device of Claim 10 wherein said core exhibits a bobbin construction and said closure member comprises a sleeve arranged to envelop said bobbin and to mate with the ends thereof, and wherein said filler material comprises an epoxy resinous material containing particles of ferrite composition dispersed throughout, which is injected into gaps between said sleeve and said bobbin ends.

12. In the manufacturing of an inductive device having a winding on a core, a closure member in engagement with said core and thereby substantially enclosing said winding, and a gap between portions of said closure member and said core, a method of controlling the magnetic effect of said gap comprising the step of injecting into said gap a measured quantity of flowable filler material containing particles of selected magnetic properties.

13. The method of manufacturing of an inductive device of Claim 12 further comprising first determining the desired effect of said filler material and then selecting particles for dispersal therein to yield the requisite effect for a measured amount of injected filler material.

14. The method of manufacturing an inductive device of Claim 13 wherein said particle selection includes one or more of the following criteria; selection of particle type by its magnetic characteristics, selection of particle size, selection of ratio of particle types, and selection of particle concentration in said filler material.

15. The method of manufacturing of an inductive device of Claim 12 wherein said core exhibits a bobbin construction and said closure member comprises a sleeve arranged to envelop said bobbin and to mate with the ends thereof, and wherein said filler material comprises an epoxy resinous material containing particles of ferrite composition dispersed throughout, which is injected into the gap between said sleeve and the end of said bobbin.

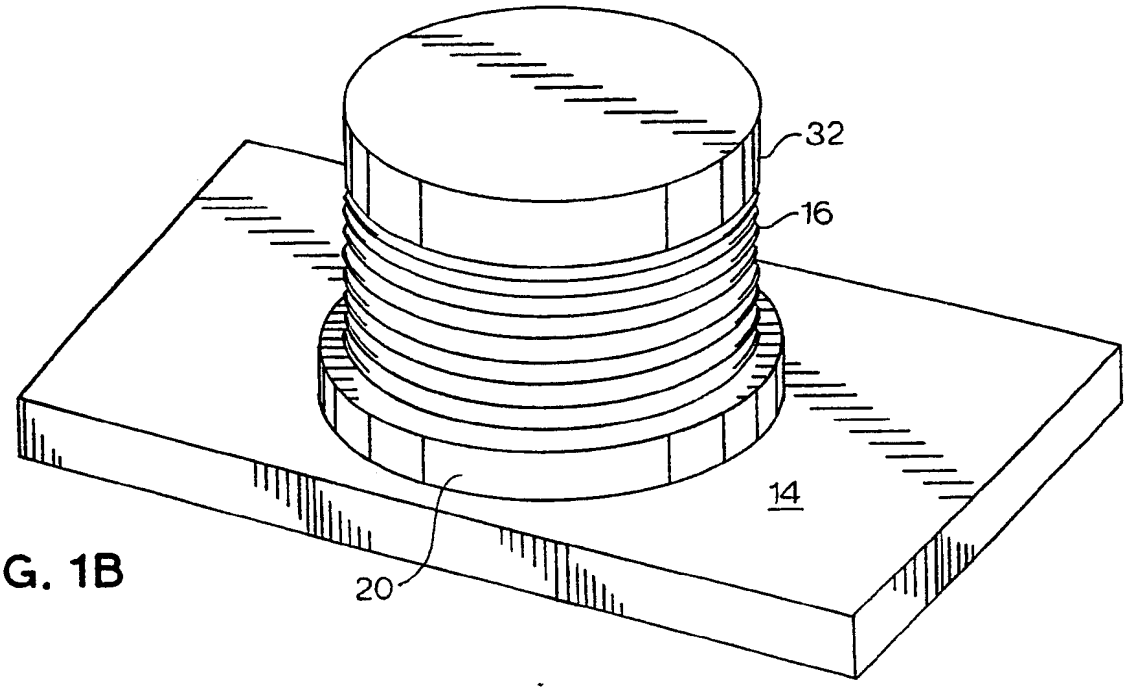

FIG. 1B

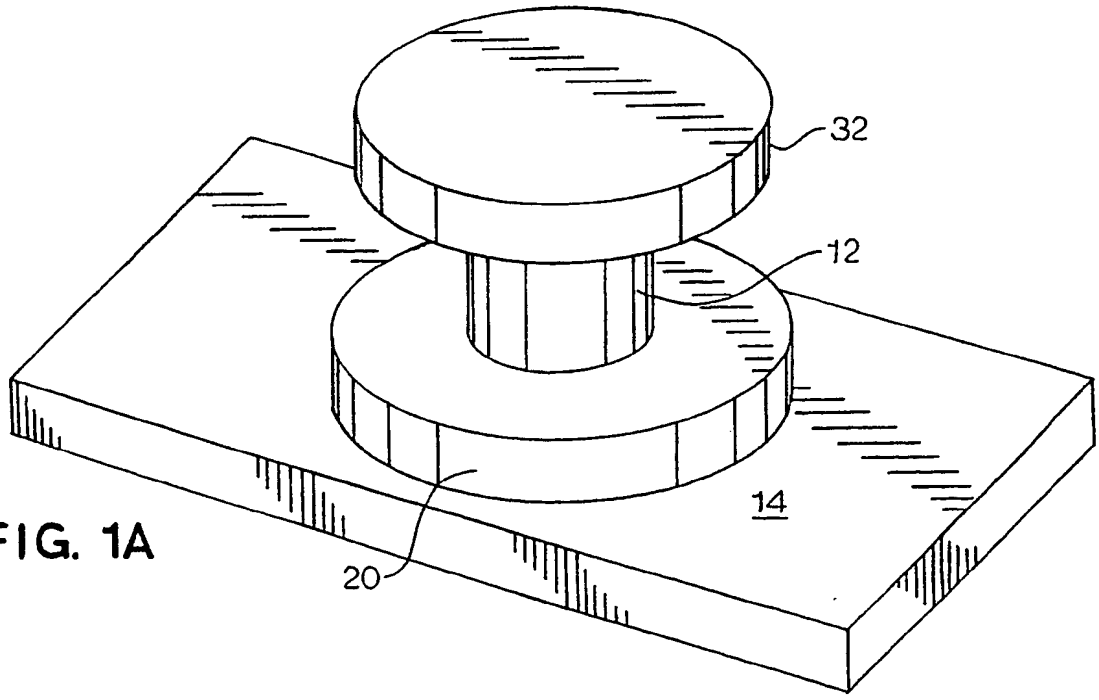

FIG. 1A

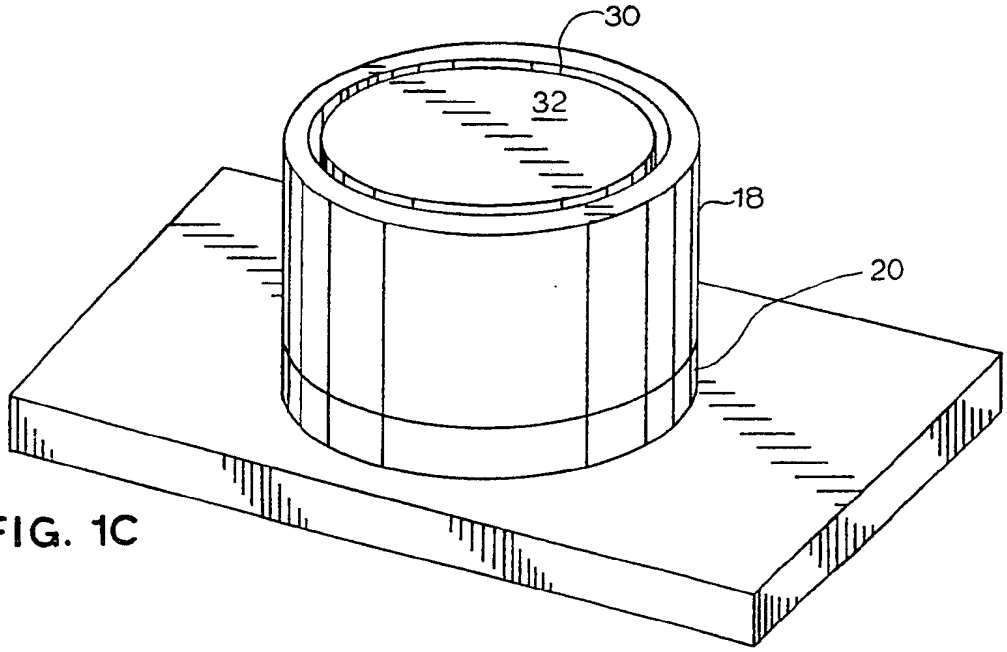

FIG. 1C

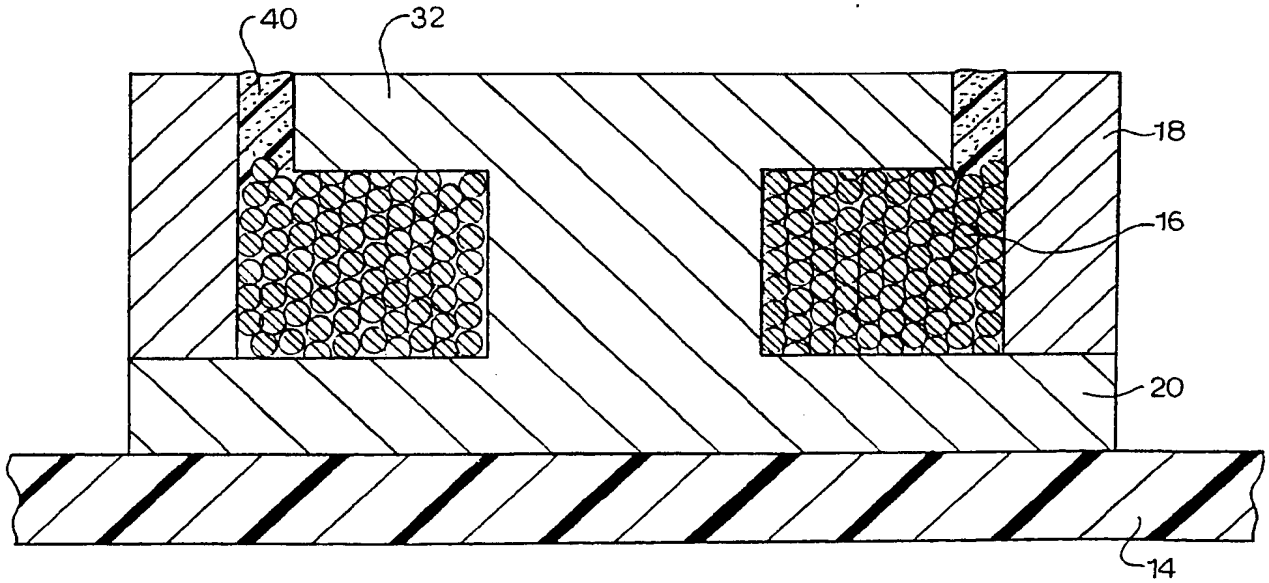

FIG. 2

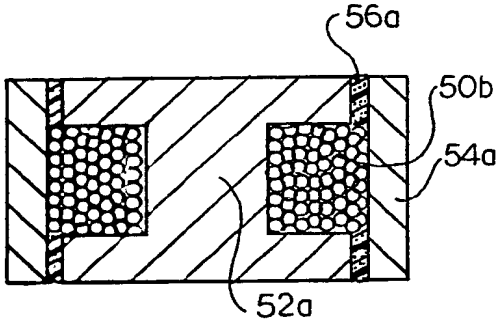

FIG. 3

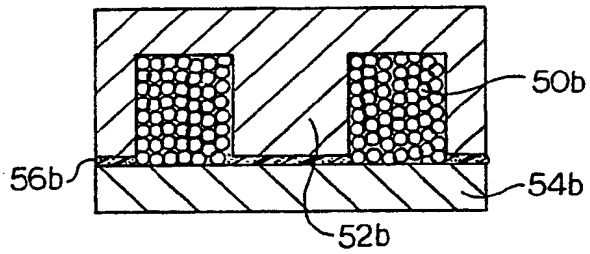

FIG. 4

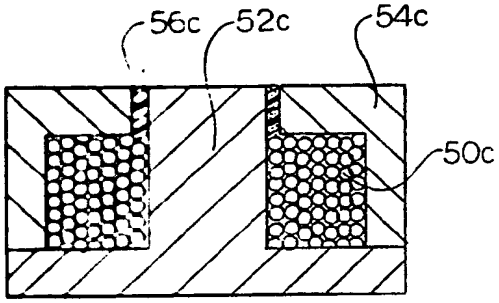

FIG. 5

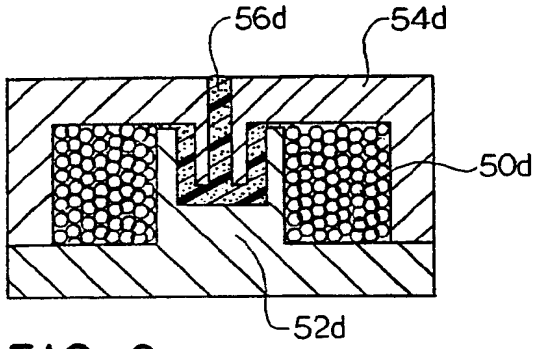

FIG. 6

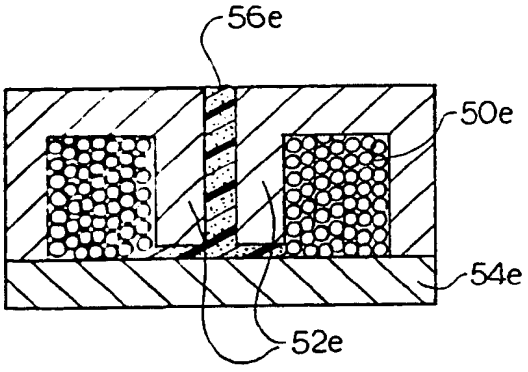

FIG. 7

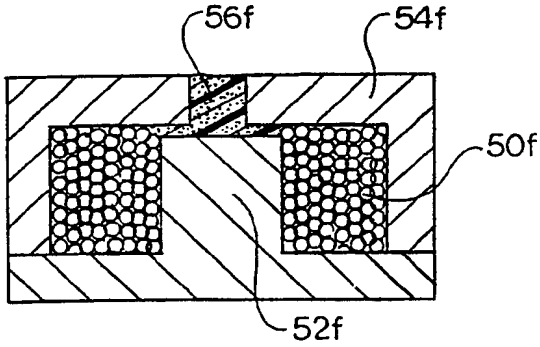

FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/06254

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): H01F 17/04; H01F 27/26; H01F 41/02

US. CL.: 29/606; 336/83, 178

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	29,605,606,607; 336/83, 178, 212, 233

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 2,976,502 (HILL) 21 MARCH 1961 See entire document.	1,2, 5-7 9,10,12-14
X	US, A, 2,962,679 (STRATTON) 29 NOVEMBER 1960 See entire document.	1,2,5-7 9,10,12-14
X	JP, A, 54-114716 (MIWA) 09 JULY 1979 See entire document.	1,2,5-7 9,10,12-14
X	US, A, 4,717,901 (AUTENRIETH ET. AL.) 05 JANUARY 1988 See entire document.	1,2,4-15
Y	US, A, 2,850,707 (WROBLEWSKI ET. AL.) 02 SEPTEMBER 1958 See entire document.	3
A	US, A, 3,663,913 (KATO ET. AL.) 16 MAY 1972 See entire document.	

* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
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